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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Vassoudevane LEBONHEUR ET AL.

Serial No.: 09/964,709

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For: METHOD OF IMPROVING THERMAL PERFORMANCE IN FLIP CHIP/INTEGRAL HEAT SPREADER PACKAGES USING LOW MODULUS THERMAL INTERFACE MATERIAL

Examiner: Alonzo Chambliss

Art Unit: 2827

AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

November 29, 2002

Sir:

The following amendments and remarks are submitted in the above-identified application in response to the Office Action mailed August 28, 2002.

IN THE DRAWINGS:

By a separate Proposed Drawing Correction filed herewith it is proposed to correct the location of a lead line in Figure 1 of the drawings as shown on the copy of Figure 1 attached to the Proposed Drawing Correction.

IN THE SPECIFICATION:

Please amend the specification as follows:

On pages 1 and 2, the title should be amended to read --IMPROVING THERMAL PERFORMANCE IN FLIP CHIP/INTEGRAL HEAT SPREADER PACKAGES USING LOW MODULUS THERMAL INTERFACE MATERIAL--.

On page 9, the paragraph between lines 8-17 should be amended to read as follows:

Gel thermal interface material 6, before curing, has properties similar to greases, e.g., a high bulk thermal conductivity (1-20 W/m°K) and a low surface energy. It conforms well to surface irregularities upon being dispersed as a liquid onto the flip chip and/or lid and sandwiched therebetween during assembly of the package, which contributes to thermal contact resistance minimization. After assembly, the package is heated to thermally cure the gel material 6 and laminate it to the flip chip and lid. In the example embodiment curing is conducted at 125°C for one hour. The thickness of the cured gel interface material 6 in the package 1 is on the order of 0.001 – 0.010 inch, but other thicknesses could be used.

IN THE CLAIMS:

Please cancel claims 7, 19 and 25 and amend the claims as follows:

1. (Amended) A semiconductor die package comprising:

a semiconductor die;

a heat spreader; and

a thermal interface material between the semiconductor die and the heat spreader, wherein the thermal interface material has a modulus of elasticity in the range of 1-500 kPa, and wherein the post end-of-line and post reliability testing thermal

resistance of the thermal interface between the semiconductor die and the heat spreader is < 1cm^2 °C/Watt.

6. (Amended) A semiconductor die package comprising:

a semiconductor die;

a heat spreader; and

a thermal interface material between the semiconductor die and the heat spreader, wherein the thermal interface material has a modulus of elasticity in the range of >5 kPa-500 kPa, and

wherein the thermal interface material is a cured, crosslinked polymer gel which is filled with material selected from the group consisting of metal and ceramic.

8. (Amended) The semiconductor die package according to claim 1, wherein the thermal interface material is a cured, crosslinked polymer gel.

10. (Amended) The semiconductor die package according to claim 8, wherein the thermal interface material has a bulk thermal conductivity of 1-20 W/m°K.

11. (Amended) The semiconductor die package according to claim 1, wherein the thermal interface material has a bulk thermal conductivity of 1-20 W/m°K.

13. (Amended) A method of making a semiconductor die package comprising:

assembling a semiconductor die and a heat spreader with a thermally conductive gel therebetween; and

curing the gel to form a thermal interface material which has a modulus of elasticity in the range of 1-500 kPa, and wherein the thermal resistance of the cured gel between the semiconductor die and the heat spreader is <1cm^2 °C/Watt.

16. (Amended) The method according to claim 13, wherein the gel has a bulk thermal conductivity of 1-20 W/m°K.

18. (Amended) A method of making a semiconductor die package comprising:

assembling a semiconductor die and a heat spreader with a thermally conductive gel therebetween; and

curing the gel to form a thermal interface material which has a modulus of elasticity in the range of > 5 kPa-500 kPa, and wherein the thermal resistance of the cured gel between the semiconductor die and the heat spreader is <1cm^2 °C/Watt.

24. (Amended) A method of dissipating heat from a semiconductor die package, comprising:

transferring heat from a semiconductor die in a semiconductor die package to a heat spreader in the package with a thermal interface material between the semiconductor die and the heat spreader;

wherein the thermal interface material is a gel which has a modulus of elasticity in the range of 1-500 kPa, and wherein the thermal resistance of the gel is <1 cm^2 °C/Watt.

26. (Amended) A method of dissipating heat from a semiconductor die package, comprising:

transferring heat from a semiconductor die in a semiconductor die package to a heat spreader in the package with a thermal interface material between the semiconductor die and the heat spreader;

wherein the thermal interface material is a cured, crosslinked polymer gel which is filled with material selected from the group consisting of metal and ceramic.

REMARKS

By the foregoing amendments, the title of the specification has been changed to that suggested in the outstanding Office Action and a correction has been made in the units identifying high bulk thermal conductivity on page of the specification. By the Proposed Drawing Correction filed herewith it is proposed to correct a lead line in Figure 1 from the reference number 7 to correctly denote the location of the thermal grease between the lid 3 and the heat sink 5 as referred to on page 8 of the specification, line 4. Claims 7, 19 and 25 have been canceled and claims 1, 6, 8, 10, 11, 13, 16, 18, 24 and 26 have been amended. Thus, claims 1-6, 8-18, 20-24 and 26-29 remain in the application. Claims 28 and 29 are allowed.

Claims 10 and 11 were objected to in the outstanding Office Action because of informalities therein as referred to on page 2 of the outstanding Office Action. Responsive to this objection, by the above amendments the suggested change in the units of the bulk thermal conductivity has been made in claims 10 and 11 and on page 9, line 9 of the specification.

Claims 6, 8, 18 and 26 were rejected in the outstanding Office Action under 35 USC 112, second paragraph, as being indefinite for the reasons stated on page 3 of the Office Action. Responsive to this rejection, by the above amendments claims 6, 18 and 26 have been amended to as to be in independent form while reciting that the modulus of elasticity of the thermal interface material is in the range of < 5kPa-500kPa. In view of these changes, it is respectfully submitted that there is no double inclusion in the claims. The objectionable expression "lightly" has also been deleted from claim 8. Therefore, the claims are now believed to be proper under 35 USC 112, second paragraph.

Claims 1-3 and 6 were rejected in the outstanding Office Action under 35 USC 102(e) as being clearly anticipated by the patent to Chen et al, U.S. Patent 6,403,882, as stated on pages 3 and 4 of the Office Action.

Claims 4 and 5 have been rejected in the Office Action under 35 USC 103(a) as being unpatentable over Chen, et al in view of Seyyedy, U.S. Patent 6,221,753, and the patent to Vogel, et al, U.S. Patent 6,317,326. The patents are combined in this rejection for the reasons and in the manner set forth on pages 5 and 6 of the Office Action.

Claims 8-18, 20, 21, 23, 24, 26 and 27 have been rejected under 35 USC 103(a) as being unpatentable over Chen, et al in view of Seyyedy, as applied to claim 1 and further in view of Schoenstein et al, U.S. Patent No. 6, 162,663, as stated on pages 6-10 of the Office Action.

Claim 22 is rejected under 35 USC 103(a) as being unpatentable over Chen et al and Schoenstein et al as applied to claims 13 and 21 in further view of Vogel et al as indicated on pages 10 and 11 of the Office Action.

These rejections are hereby traversed and reconsideration thereof is respectfully requested in view of the above amendments to the claims and applicants' remarks set forth below.

Claims 7, 19 and 25 were indicated on page 11 of the outstanding Office Action to be allowable if rewritten to overcome the rejection under 35 USC 112, second paragraph, and to include all of the limitations of the base claim and any intervening claims. Responsive to this indication of allowable subject matter, by the above amendments the limitations of canceled claims 7, 19 and 25 have been added to the claims from which they depended, namely, independent claims 1, 13 and 24, respectfully. Accordingly, these claims and the claims dependent thereon are believed to be in condition for

allowance. Therefore, reconsideration and allowance of the claims as amended are respectfully requested.

Claims 6, 18 and 26 are now rewritten in independent form and each amended to recite that the thermal interface material between the semiconductor die and the heat spreader of the semiconductor package has a modulus of elasticity in the range of > 5 kPa -500 kPa. The claims also specify that the thermal interface material is a cured, crosslinked polymer gel which is filled with material selected from the group consisting of metal and ceramic. This combination of features in a thermal interface material has been found to ensure no jeopardy for thin film cracking and thin film de-lamination in the package configuration with improved package thermal performance in response to temperature/humidity exposure as shown in Figure 7 of the application drawings and as discussed on page 14 of the specification as to the criticality of maintaining the modulus to >5 kPa. The cited references do not suggest nor render obvious this specific seimconductor package and method of the present invention.

The primary reference to Chen, et al. is directed to a protective cover plate for flip chip assembly backside wherein the thermal interface material 45, Figs. 2 and 3, is an adhesive which can have a Young's modulus of elasticity of 10,000 psi (68,950kPa), or preferably about 1,000 psi (6,895 kPa). These moduli are in excess of an order of magnitude greater than the modulus of the thermal interface material of the present invention wherein the thermal interface material has a modulus of elasticity in the range of 1-500 kPa, for example. The thermal interface material 45 in Chen, et al is also not a gel as in the present invention.

The secondary references relied upon in the outstanding rejections of applicants claims do not provide for the aforementioned deficiencies of Chen, et al. The patent to Schoenstein et al is directed to dissipation of heat from a circuit board having bare silicon

chip mounted thereon wherein a gel of the thermal interface material has a compression modulus of 13,080 kPa, which is substantially higher than the gel material of the present invention modulus of elasticity of only 1-500 kPa, for example. Schoenstein et al also do not recognize the criticality of providing the modulus of elasticity of >5 kPa for improved package thermal performance in response to temperature/humidity exposure as achieved by the present invention The thermal interface material of the reference in its cured state is <u>a solid material with a measurable</u> hardness, see col. 6, lines 54-56, and col. 7, lines 11-30. In the example embodiment of the present invention the thermal interface material is applied as a grease and cured to a gel with a modulus of elasticity of only 1-500 kPa. It is not a solid material with a cohesive strength greater than its adhesive strength as in Schoenstein et al. Likewise, the patents to Vogel et al and Seyyedy fail to disclose or suggest, 35 USC 103, the aforementioned specific combination of the features of the present invention as recited in applicants claims 6, 18 and 26 as amended. Accordingly, reconsideration and allowance of these claims are respectfully requested.

Please charge any shortage in the fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account No. 01-2135(219.40446X00).

Respectfully submitted,

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